



**USAID | JORDAN**  
FROM THE AMERICAN PEOPLE

# WATER REUSE AND ENVIRONMENTAL CONSERVATION PROJECT

CONTRACT NO. EDH-I-00-08-00024-00 ORDER NO. 04

## TASK 4 WADI MOUSA REUSE PILOT PROJECT TECHNICAL ASSISTANCE PLAN

DRAFT SUBMITTED JULY 2012

IMPLEMENTED BY AECOM



# WATER REUSE AND ENVIRONMENTAL CONSERVATION PROJECT

CONTRACT NO. EDH-I-00-08-00024-00 ORDER NO. 04

## WADI MOUSA REUSE PILOT PROJECT TECHNICAL ASSISTANCE PLAN

**DRAFT**  
**JULY 2012**

Submitted to:  
USAID Jordan

Prepared by:  
AECOM

### DISCLAIMER:

The authors' views expressed in this document do not necessarily reflect the views of the United States Agency for International Development or the United States Government.



## Contents

Executive Summary .....	i
1. Background.....	1
1.1 Objective of Technical Assistance.....	1
1.2 Scope of the Report.....	1
2. Site Description.....	2
2.1 Wadi Mousa WWTP.....	2
2.2 Reclaimed Water Distribution System .....	2
2.3 Pilot Project Irrigation Site.....	4
2.4 Pilot Project Operation .....	5
3. General Approach.....	6
3.1 Challenges.....	6
3.2 Funding Source for Near-Term Capital Improvements .....	7
4. Financial Assistance Plan .....	7
4.1 Proposed Work and Required Funding .....	8
4.2 Justification .....	8
5. Technical Assistance Plan .....	10
5.1 Coordination with HFDB for pilot project supervision.....	11
5.2 Providing assistance to the management of the irrigation system operation and maintenance.....	11
5.3 Developing Wadi Mousa Project Database .....	12
5.4 Providing technical assistance for improving cropping pattern .....	13
5.5 Assisting farmers in improving the quality of their products .....	13
5.6 Training farmers and the WUA staff .....	14
5.7 Socioeconomic Status Monitoring .....	15
5.8 Improving Hygiene by Establishing Access to Clean Water .....	15
6. Stakeholders.....	15
7. Technical Assistance Schedule.....	16

USAID Water Reuse and Environmental Conservation Project  
Wadi Mousa Reuse Pilot Project Technical Assistance Plan

References .....	18
APPENDIX A .....	A-1
APPENDIX B .....	B-1
APPENDIX C .....	C-1
APPENDIX D .....	D-1
APPENDIX E .....	E-1

## **List of Acronyms**

BRDP	Badia Research and Development Program
HDPE	High density polyethylene
HFDB	Hashemite Fund for Development of Jordan Badia
JCC	Jordanian Cooperative Corporation
JD	Jordanian dinar
MOU	Memorandum of understanding
MWI	Ministry of Water and Irrigation
NGO	Non-governmental organization
PRA	Petra Regional Authority
RIAL	Reuse for Industry, Agriculture and Landscaping
RKC	Reuse knowledge center
TRG	Training Resources Group
UPVC	Un-plasticized polyvinyl chloride
WAJ	Water Authority of Jordan
WRIP	Water Reuse Implementation Project
WUA	Water Users' Association
WWTP	Wastewater treatment plant

USAID Water Reuse and Environmental Conservation Project  
Wadi Mousa Reuse Pilot Project Technical Assistance Plan



## Executive Summary

This planning report is prepared as part of the USAID Water Reuse and Environmental Conservation Project (Project).

The primary objective of the technical assistance plan is enhance the sustainability of an existing 8-year old reuse pilot project by renewal and replacement of equipment and materials that have reached the end of their service life. This will be accomplished by implementing lessons learned from the previous years of experience at this location; these lessons are essential to establishing best practices for the long-term sustainability of farming with reclaimed water irrigation in Jordan.

The primary focus will be on training farmers on better crop selection, rotation, and harvesting, and in increasing their understanding of how such changes can either make their crops more marketable or enable them to produce a self-sustaining year-round supply of feed for their own livestock. There will also be training on financial responsibility, accountability, and planning, as needed, to achieve economic viability.

A landmark water reuse pilot project was established by the USAID Water Reuse Implementation Project (WRIP, 2002-2004) in Wadi Mousa, aiming at enhancing livelihood in the local community. This pilot project was later expanded during the USAID Water Reuse for Agriculture, Industry and Landscaping Project (RIAL, 2004-2007).

The project site is adjacent to Wadi Mousa wastewater treatment plant (WWTP). According to the RIAL project report (Final Report, 2008), up to 58.7 ha was irrigated with reclaimed water for growing fodder crops and fruit crops during the RIAL project. Farmers practicing reclaimed water irrigation belong to Sad Al Ahmar Association (WUA). The association has 114 members (over 200 people including their families), of which about 40 members are directly engaged with the pilot project.

Based on the site investigation conducted by the Project team during 2011, the team identified challenges faced by the farmers and WUA, and opportunities for providing technical assistance to improve the overall condition of the site.

Stakeholders have expressed, as a primary concern, the need to identify an external source of funding to cover the near-term capital improvements. This report presents the capital budget, from a yet-to-be-identified external funding source, necessary to implement a proposed renewal and replacement program. An external funding source is proposed to pay for restoring the most critical components of aged and otherwise unsuitable equipment and materials, based on a detailed needs assessment.

The balance of the renewal and replacement work is proposed to be implemented gradually thereafter and paid for by the various responsible stakeholders in the coming years. The proposed capital budget for an external funding source is presented with justification as typically needed to support a grant application.

Developing a financial plan to source the necessary funding is beyond the Project's current scope of work. In accordance with the scope of work presented in the Project contract with USAID, reuse pilot activities are to consist of "extending technical assistance for the preparation of detailed design and tender documents for the implementation of water reuse ..." in recognition that "this would ultimately allow three NGOs to compete for receiving USAID grants under a separate procurement instrument."

The estimated cost to implement the proposed near-term renewal and replacement improvements is \$80,300 USD. The items included in the estimate are summarized in Table ES-1. The proposed financial assistance includes the coverage of costs for renewal and replacement improvements to the reclaimed water irrigation system, such as the repair of major leakage and re-installation of disk filters, which are essential to prevent the drip irrigation emitters from clogging. It also includes the cost for replacing a tractor. A list of the items included in the requested funding is shown in Table ES-1.

**Table ES-1: Breakdown of items and estimated costs proposed to be covered by an external funding source**

Item	Expected cost (JOD)	Expected cost (USD)	Responsibility
Repair sand filters	900	1,300	WUA/HFDB
Rehabilitate farm head unit parts	17,600	24,800	WUA/HFDB, or farmers
Repair leakage from head units	2,200	3,100	WUA/HFDB, or farmers
Replace drip irrigation laterals and associated parts	8,200	11,600	Farmers
Replace tractor	24,500	34,500	WUA/HFDB
Training materials	3,500	5,000	Project
TOTAL	56,900	80,300	

By eliminating immediate financial burdens and following up with additional technical assistance, the pilot project operation is expected to generate a surplus of funds that is adequate to sustain the pilot project financially. The grant request also includes the cost associated with the development and implementation of training sessions.

The following technical assistance activities are proposed in this plan:

- Coordination with the Hashemite Fund for Development of Jordan Badia (HFDB) to supervise the pilot  
*HGDB is the local Jordanian organization which assumes responsibility for supervising and managing the project, and the Project will coordinate with HFDB for the technical assistance implementation*
- Providing assistance to the management of the irrigation system operation and maintenance  
*Farmers need more training and assistance in managing their on-farm irrigation activities including the management of their finance*
- Development of Wadi Mousa project data base  
*A database is needed to build up an information base for proper management and decision making of the project*
- Providing technical assistance to improve cropping pattern  
*Applying the right cropping pattern that suits not only the agricultural, economic, and environmental aspects of the area but also the social and cultural aspects*
- Assisting farmers to improve the handling of agricultural products  
*Proper handling of agricultural products affects the marketability of their products*
- Training farmers and WUA staff  
*The training sessions will be developed in coordination with HFDB, and will help building the capacity for WUA and farmers to self-sustain the project*

- Monitoring the socioeconomic status of reclaimed water users  
*The socioeconomic study will monitor and evaluate the progress of the project and the results will be used for the adaptive management of the project*
- Establishing a fresh water access service (future plan)  
*Fresh water should be used for the hygiene of the farmers and workers but this is not included for this phase of the assistance.*

The most critical part of the technical assistance is to build capacity for WUA and the farmers and support their effort to sustain the pilot technically and financially. Coordination with HFDB, which is currently supervising the pilot, and other stakeholders is the first step. Other elements of the technical assistance, including trainings will follow, once responsibilities of stakeholders are clarified. A socioeconomic study will be conducted to evaluate the current socioeconomic status of the Wadi Mousa farmers and to monitor the success of the technical assistance.

Identification of an external funding source is necessary for the WUA and farmers to get back on a sustainable track in their financial management, and also, for the Project team to build confidence and working relationships with the WUA and farmers. The scope of technical assistance may need to be reconsidered if no external source of implementation funding can be identified.

## 1. Background

The water reuse pilot project in Wadi Mousa was first established by USAID through the Water Reuse Implementation Project (WRIP 2002-2004), and was expanded during the Water Reuse for Agriculture, Industry and Landscaping Project (RIAL 2004-2007). The RIAL project ended in 2007. The pilot project has since been operating under the supervision of the Hashemite Fund for Development of Jordan Badia (HFDB).

The Wadi Mousa pilot irrigates with reclaimed water from the Wadi Mousa WWTP. In 2004, the delivery of the reclaimed water to the pilot project site was formalized in a Memorandum of Understanding (MOU) between the Petra Regional Authority (PRA), the Water Authority of Jordan (WAJ), and the Badia Research and Development Program (BRDP). This MOU guaranteed farmers access to the reclaimed water for a fee of 1 Jordanian Dinar per cubic meter (JD/m<sup>3</sup>) (RIAL baseline report, 2004). Farmers working at the pilot site are members of the Sad Al Ahmar Association also known as the Water Users Association (WUA). There are 40 farm units within the pilot site, and as of September 2011, 26 farm units were fully utilized. The majority of the rest were partially utilized, while two farm units had ceased to operate.

The Project team conducted a detailed review of the Wadi Mousa pilot project, including currently irrigated areas, irrigation networks, and the socioeconomic conditions at Wadi Mousa (Task 4 Technical Memorandum II, 2011). This technical assistance plan is based on the findings from the review plus additional investigations conducted to clarify the responsibilities of the stakeholders.

### 1.1 Objective of Technical Assistance

The primary objective of the technical assistance plan is enhance the sustainability of an existing 8-year old reuse pilot by repairing, renovating, and replacing equipment and materials that have reached the end of their service life. This will be accomplished by implementing lessons learned from the previous years of experience at this location; these lessons are essential to the long-term sustainability of farming with reclaimed water irrigation.

There will be a primary focus on training farmers about how better crop selection, rotation, and harvesting can make their crops more marketable, and also, on financial responsibility, accountability, and planning as needed to achieve economic viability. The project will start technical assistance by addressing the short term problems that may impede its progress, and will also be setting long term approaches that will support its sustainability.

It is important to understand that long-term solutions must be culturally consistent with the traditions of the Bedouin people of the Wadi Mousa area. Such activities may involve the use of forage crops and native forage plants and trees in a way that can provide a year-round, self-sustaining supply of feed that can support herding and raising livestock. Traditional farming, coupled with modern jobs related to the tourism and service trades generated from nearby Petra, are the primary livelihoods for the residents of Wadi Mousa.

### 1.2 Scope of the Report

This report outlines the concept level description of technical assistance activities to be implemented in cooperation with farmers and key stakeholders. This report identifies detailed plans over a two-year period beginning with the identification of an external funding source for near-term capital improvements.

This report also presents a proposed capital budget to implement a proposed renewal and replacement of aged and otherwise unsuitable equipment and materials based on a detailed needs assessment. The capital budget is presented with justification as typically needed to support a grant application.

Developing a financial plan to source the necessary funding is beyond the Project's current scope of work. In accordance with the scope of work as presented in the Project contract with USAID, reuse pilot activities are to consist of "extending technical assistance for the preparation of detailed design and tender documents for the implementation of water reuse" in recognition that "this would ultimately allow three NGOs to compete for receiving USAID grants under a separate procurement instrument."

## **2. Site Description**

Wadi Mousa is located north of Petra, in the Ma'an Governorate, with a population of approximately 28,000. The area is characterized by hot summers and cold dry winters. Rainfall occurs between November and April in an irregular pattern, and the annual rainfall is less than 200 mm (RIAL Environmental Review, 2006). The infrastructure of the Wadi Mousa pilot includes sand filters and a pump station within the Wadi Mousa WWTP boundary, a reclaimed water transfer main, an irrigation water sub-main with irrigation head units, and farm units.

### **2.1 Wadi Mousa WWTP**

The treatment process includes preliminary treatment (coarse screen and grit removal), secondary biological process, final clarifier, effluent polishing lagoon, chlorination process, sludge holding tank and sludge drying beds (see Figure 1). Odor control units are provided to minimize odor emissions. Design treatment capacity is 3,700 m<sup>3</sup>/d. As of 2010, Wadi Mousa WWTP is receiving approximately 3,000 m<sup>3</sup>/d of wastewater and generating over 2,800 m<sup>3</sup>/d of reclaimed water.

The quality of reclaimed water meets Jordanian standards for reuse as irrigation water. Effluent water quality data provided by WAJ for 2011 is summarized in Table 1. Note that data for the month of December 2011 was not available at the time of this report.

WAJ collects samples for effluent quality analyses from the onsite effluent polishing ponds. Before leaving the site for irrigation, water is routed through sand filters located at the reclaimed water pump station.

### **2.2 Reclaimed Water Distribution System**

A 1,700-m<sup>3</sup> irrigation water storage pond is located within the WWTP boundary. There are two irrigation pumps and three sand filter units next to the irrigation pond. According to the drawings prepared by the RIAL project, the irrigation water conveyance main is a 350-mm ductile iron pipe. A 100-mm ductile iron pipe diverts part of the reclaimed water for the farm unit next to the treatment plant and also for the irrigation of plants within the WWTP.

USAID Water Reuse and Environmental Conservation Project  
Wadi Mousa Reuse Pilot Project Technical Assistance Plan

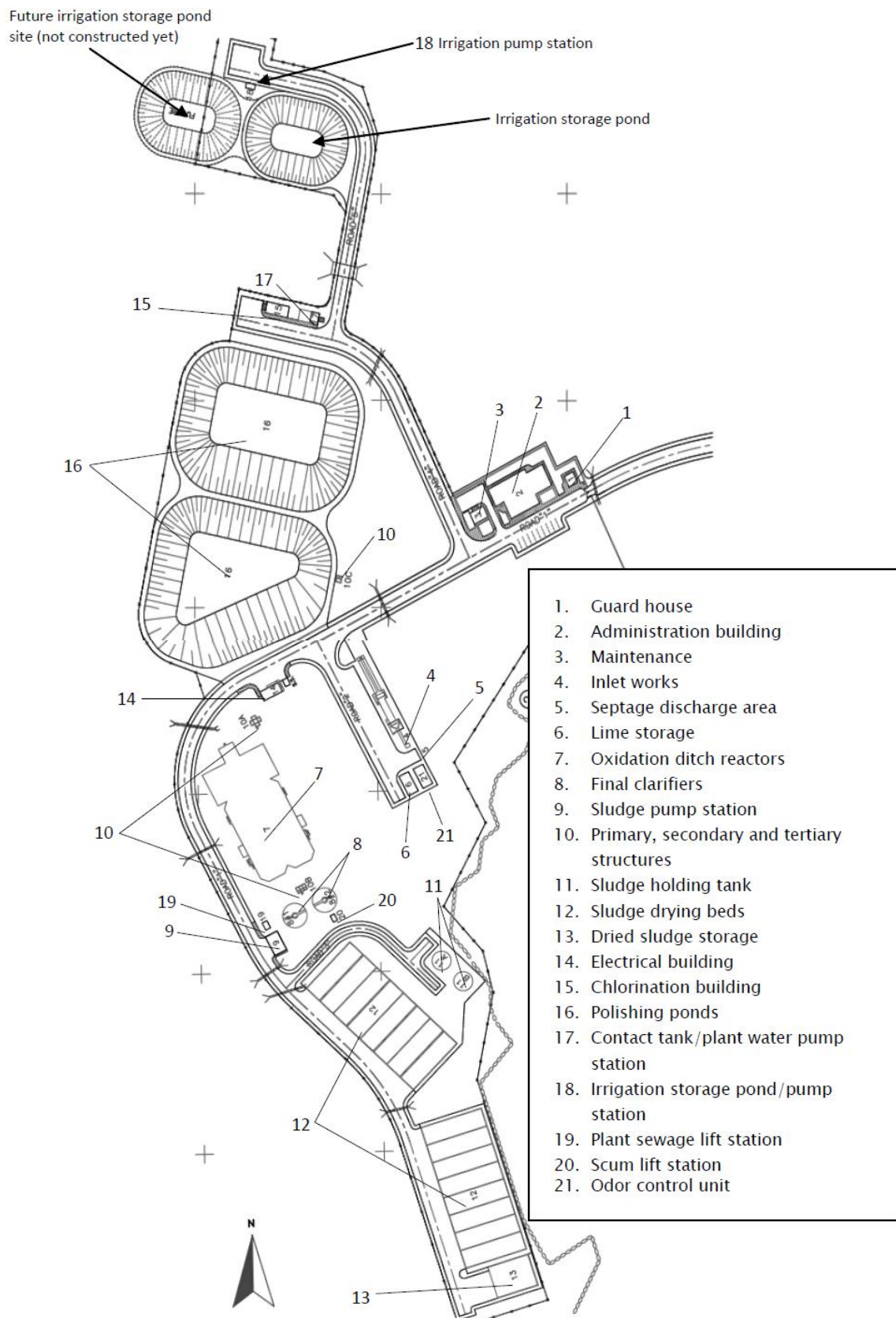


Figure 1: Wadi Mousa WWTP Site Layout



**Table 1. Wadi Mousa WWTP Effluent Quality for January through November 2011**

Month	pH, std. units	Filtered BOD <sub>5</sub> , mg/L	TSS, mg/L	TDS, mg/L	E.Coli, MPN/100 ml	PO <sub>4</sub> , mg/L	NO <sub>3</sub> , mg/L	TN, mg/L	NH <sub>4</sub> , mg/L
January	7.99	3	5	801	1.8	15.08	47.85	11.79	0.5
February	7.66	3	<5	826	1.8	10.73	43.3	11.99	0.5
March	8.46	3	6	906	1.5	13.48	48.27	12.3	0.5
April	8.4	7.5	7	816	1.8	15.02	48.27	13.15	0.51
May	8.32	6	7	888	40.4	16.18	42.96	10.9	0.5
June	7.9	3	7	819	1.8	33.4	43.8	11.4	0.5
July	8.59	3	10.5	789	17.4	10.8	45.5	12.1	0.5
August	8.25	3	8.5	876	1.8	17.18	47.47	12	0.5
September	7.81	3	7	806	1.8	14.45	45.44	12.19	0.57
October	7.61	3	8.5	830	1.8	22.4	50	13.1	0.5
November	7.22	3	7	834	1.8	6.94	52.9	13.3	0.5
<b>Average</b>	8.02	3.7	7.4	836	3.0	15.97	46.89	12.20	0.51

Source : WAJ, 2012

Reclaimed water is diverted to 63-mm high-density polyethylene (HDPE) sub-main lines leading to the irrigation head units and to each farm unit. Based on the field investigation conducted by the project team in 2011, the existing irrigation network for the water reuse pilot site consists of an underground 160-mm un-plasticized polyvinyl chloride (UPVC) main conveyance line, two 90-mm and 160-mm HDPE main lines conveying water to 41 farms, as well as farms' irrigation systems. The irrigation system at each farm includes a sub-main line, manifolds, laterals, and head units.

## 2.3 Pilot Project Irrigation Site

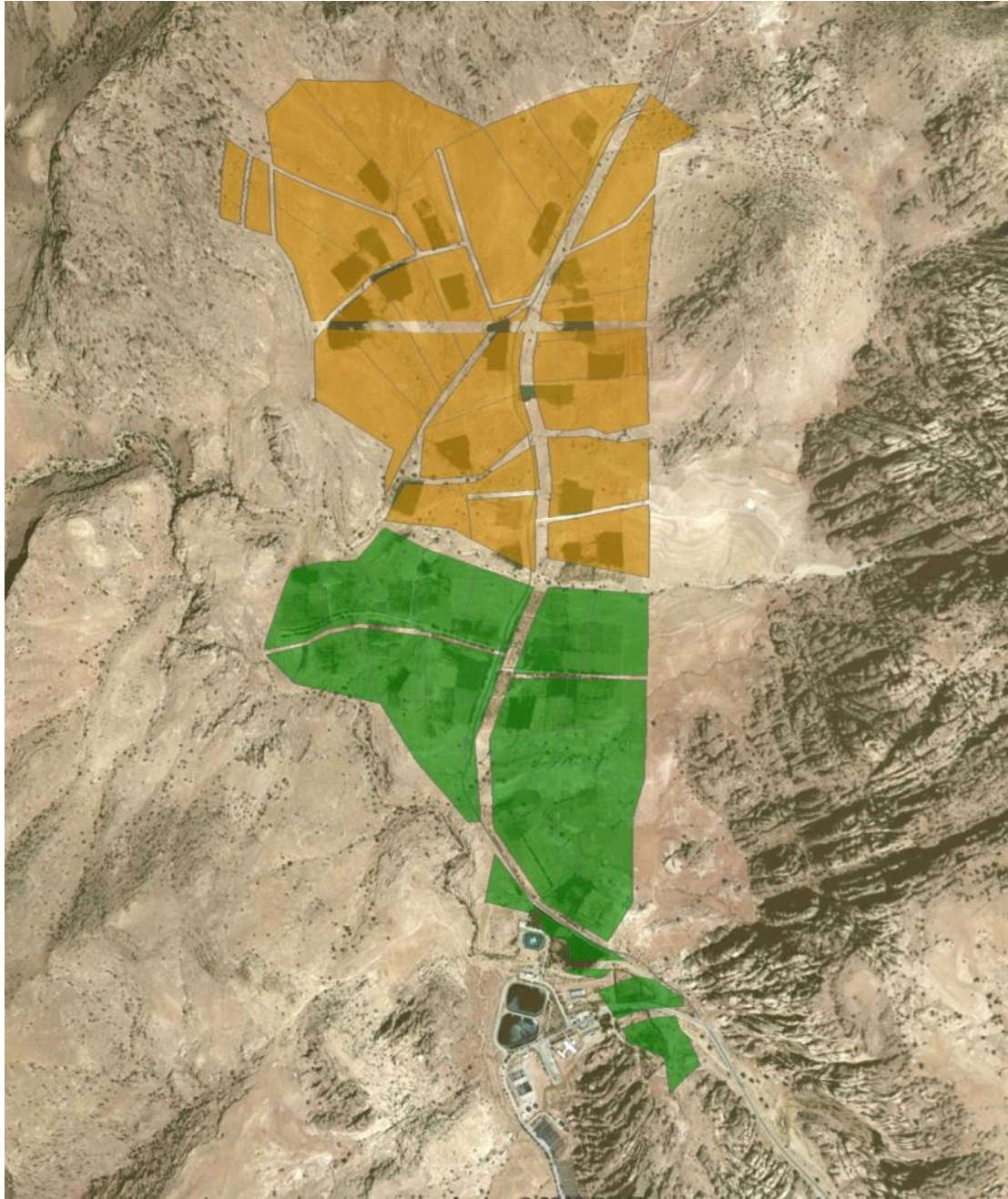
Farmers practicing reclaimed water irrigation belong to the Sad Al Ahmar Association (WUA). The association has 114 members (over 200 people including their families), of which about 40 members are directly engaged with the pilot project. The farms are categorized into two areas, depending on the phases of the project:

- Phase I: Farms cultivated under WRIP and continued under RIAL
- Phase II: Farms cultivated under RIAL as an expansion for WRIP

The pilot project started with a 6.9-ha demonstration and was later extended to 36.9 ha during the WRIP period (Phase I area). The RIAL project added another 30 ha of irrigated area (Phase II area). The layout of the water reuse pilot area is shown in Figure 2.

According to the reports prepared by RIAL, up to 58.7 ha were irrigated with reclaimed water by the end of the RIAL project (RIAL Impact Assessment, 2006), with a total of 41 farm units connected to the reclaimed water irrigation system. Wadi Mousa pilot project components mentioned in the agreement documents signed by the HFDB and WUA are:

- 34 farm units
- Machinery
- Irrigation system (the filtration unit and irrigation systems)
- Project annexes (one horse and green house)



**Figure 2: Layout of the Wadi Mousa water reuse pilot project**

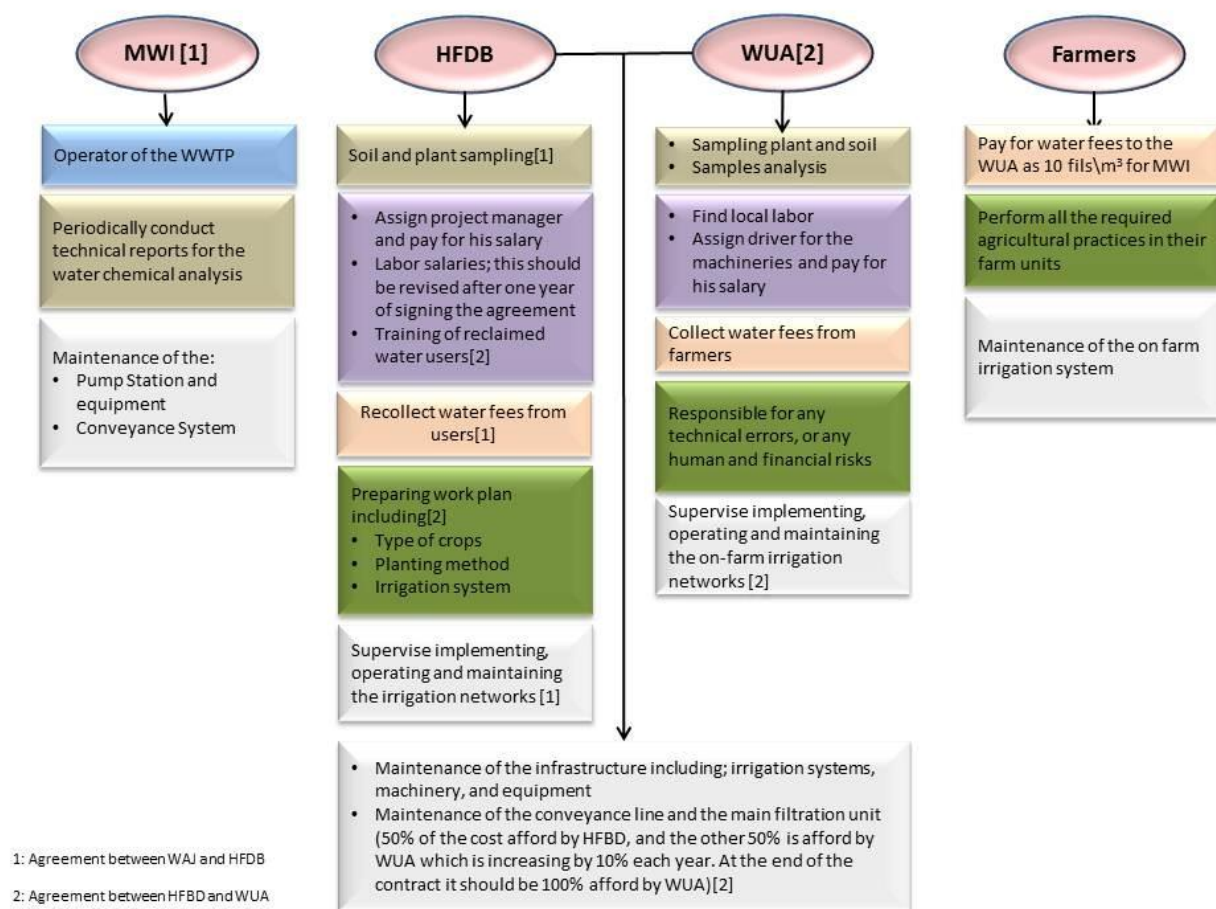
## **2.4 Pilot Project Operation**

Two agreements were signed in 2008 to proceed with the operation of the Wadi Mousa pilot project, addressing the responsibilities of stakeholders involved in the project. One agreement was signed between HFDB and WUA, and the other between WAJ and HFDB.

Both agreements will expire after five years, but are renewable by mutual consent. Responsibilities distributed among the key responsible stakeholders at the Wadi Mousa pilot project are summarized in Figure 3.

Field visits were conducted in September and December 2011 to collect data on the Wadi Mousa project sites. Details of those data gathering activities are summarized in Appendix A.





**Figure 3: Distribution of responsibility among farmers and stakeholders at Wadi Mousa pilot project according to the signed agreements.**

### 3. General Approach

The Wadi Mousa pilot project has 10 years of experience and a long history of assistance by the USAID projects. Even though tremendous efforts were spent under the RIAL project to make it become self-sustainable towards the end of the RIAL project the farmers appeared to be facing difficulties maintaining the pilot project site in as good a condition as it had been when the previous project team was fully in charge of the activities.

#### 3.1 Challenges

Based on the literature review and site investigations, two critical issues were identified as the major obstacles for sustainable operations of the pilot.

##### **Lack of supervision by a site engineer at the pilot site**

Lack of supervision by a site engineer in the past few years has resulted in abandoned farm units and poor maintenance of irrigation head units, laterals and even main conveyance lines. Most of these maintenance needs could be addressed with relatively minor expenses and minimal labor. However, if these are left unaddressed, the extent of the maintenance needs could become significant, with a much higher cost to fix the problem.

Based on the MOU between HFDB and WUA, HFDB is supposed to provide a project manager/engineer for the pilot site. An engineer was assigned to the pilot for one year after the completion of the RIAL project, but he was later discontinued.

Lack of supervision by a trusted engineer might have also caused the lack of clear understanding about the responsibilities by the stakeholders, as there has not been anybody who understands the responsibilities and duties each party has to fulfill in the past few years.

### **High maintenance cost for machinery**

According to the 2010 accounting record, over 13,000JD was spent on machinery maintenance. The record for the 2011 accounting has not been issued yet as of the time of this planning. Maintenance of the John Deere tractor, purchased under the RIAL project, is a significant cost burden for WUA because of the long lead time and high costs for replacement parts that must be special ordered and shipped from overseas. In the interest of limiting equipment downtime for repairs, WUA representatives have reported that the tractor was modified by using locally available parts and supplies. It is acknowledged that these types of repairs have negatively affected the tractor's performance.

## **3.2 Funding Source for Near-Term Capital Improvements**

Stakeholders have expressed, as a primary concern, the need to identify an external source of funding to cover the near-term capital improvements. This concern has been reinforced by the Project's Water Reuse Workshop Committee. In summary, the Project can expect less-than-enthusiastic participation by the local stakeholders on this initiative without a clear prospect for funding the necessary renewal and replacement improvements.

A capital budget is presented in Section 4 with justification to support a grant application to implement the proposed renewal and replacement project. The planned technical assistance activities presented in Section 5 are intrinsically tied to the assumption that a source for the proposed capital funding needs will be identified early in this Project. The prospect of funding is a critical starting point to gain stakeholders' confidence and cooperation.

Training is a significant component of the technical assistance plan. Stakeholder participation is essential to a successful training program. Economic viability is an expected outcome of the training so that in the future, when it comes time to re-invest hard-earned income into renewal and replacement improvements, the pilot can be economically self-sustaining.

The approach to providing technical assistance to address economic sustainability will focus on clear definition stakeholder responsibilities; organizational management capacity sustain economic benefits and best practices; organizational training to maintain farmers' practice to minimize the potential health risk; and technical proficiency to operate and maintain a productive reclaimed water irrigation system.

## **4. Financial Assistance Plan**

As discussed previously (see Figure 3 above), the responsibilities of stakeholders for the operation and maintenance of the irrigation network were described in two agreement documents. The duration of each agreement is five years (2008-2012). After 2013, the WUA will be solely responsible for the maintenance of the conveyance line, main filtration unit, and machinery. The division of responsibilities among the stakeholders to repair and

maintain the irrigation network is summarized in Table 2. An inventory of all missing, broken, and malfunctioning parts or equipment is provided in Appendix B.

**Table 2: Division of Responsibilities to Maintain and Repair the Irrigation Network among Different Parties at Wadi Mousa Water Reuse Pilot Project.**

Reclaimed Water Reuse Irrigation Network Component	Entity Responsible for Repairs and Maintenance
Sand Filters	HFDB and WUA
Pump Stations	WAJ
Transmission Main (conveyance to the project area)	WAJ
Distribution Main (conveyance within the project area)	HFDB
Distribution valve pits	WAJ
Farms head units	Farmers
On-farm irrigation networks	Farmers

#### 4.1 Proposed Work and Required Funding

The amount of funding required from an external source is estimated to be \$80,300 USD. The items included in the estimate are summarized in Table 3. A detailed list of all irrigation system renewal and replacement work is provided in Appendix C; however, the funding required from external sources is estimated to cover only those items in Appendix C that are highlighted in bold font. The balance of the renewal and replacement work that is not covered by an external funding source will be paid for and implemented by the stakeholder who is designated responsible for the necessary improvements in the years to follow.

#### 4.2 Justification

Based on the 2010 accounting record, as provided in Appendix D, the WUA had about 18,000 JOD to manage the operation of the association. In addition, approximately 2,000 JOD had been set aside for the revolving fund. In 2011 (not documented yet), however, WUA spent approximately 14,000 JOD on purchasing spare parts for the John Deere tractor (detailed information will be reported in the 2011 accounting record, to be filed to JCC), leaving only 4,000 JOD to manage the association's functions.

**Table 3: Breakdown of Items and Estimated Costs Proposed to be Covered by an External Funding Source**

Item	Expected cost (JOD)	Expected cost (USD)	Responsibility
Repair sand filters	900	1,300	WUA/HFDB
Rehabilitate farm head unit parts	17,600	24,800	WUA/HFDB, or farmers
Repair leakage from head units	2,200	3,100	WUA/HFDB, or farmers
Replace drip irrigation laterals and associated parts	8,200	11,600	Farmers
Replace tractor	24,500	34,500	WUA/HFDB
Training materials and fees	3,500	5,000	Project
<b>TOTAL</b>	<b>56,900</b>	<b>80,300</b>	

Based on the balance sheet for the WUA accounting, the WUA has been gaining between 4,000 JOD and 16,000 JOD per year as surplus, which should be sufficient for purchasing replacement parts for which WUA is responsible. However, the WUA is hesitant to use up the remaining 4,000JOD for the irrigation system rehabilitation now, due to the possibility of having to pay a significant amount of money on the tractor maintenance.

The items for the rehabilitation of reclaimed water irrigation system listed in Table 3 are critical for the continued operation of the pilot. Additional items not listed in Table 3 that are necessary to restore the irrigation system back to its original condition are provided in Appendix C. An external source of funding will be limited to restoring only the critical parts of the irrigation system. The remainder of the restoration work is to be implemented and paid for in coordination with HFDB, WAJ, WUA and the farmers, each according to their responsibilities outlined in the agreement documents.

Drip irrigation laterals are due to be replaced for the entire pilot project; however, the farmers were setting aside a portion of their income to cover replacement costs. The cost breakdown shown in Table 3 covers 50 percent of the total cost to replace drip irrigation laterals and associated parts. The remaining 50 percent will be replaced gradually in coming years at the farmers' expense. In cooperation with HFDB, the project will help farmers (through the technical assistance and training) plan to set aside funds necessary to pay for irrigation system maintenance, repairs, and replacement based on each materials' expected useful life.

The project team recommends that the John Deere tractor be replaced with a new tractor for which spare parts are readily accessible at local dealers. Prices of locally available tractors are shown in Appendix E. After consideration of farming practices in Wadi Mousa, the team recommends a model with greater than 75 horsepower. In this report, the model with second highest horsepower and price is used in the cost estimate and grant request. The option to rent a tractor was also considered, but the project team favors purchasing, based on the assessment summarized in Table 4.

The annual operational cost for rented a tractor will be greater than a purchased tractor and the cost burden will be directly on the farmers. Moreover, farmers will need to drive the tractor from the nearest government agency where the machinery is rented, and availability during harvest season cannot be guaranteed. By purchasing the tractor, the farmers would pay significantly less, and the expected cost burden to the WUA will be similar or less than their expenses for machinery prior to 2011, when they did not incur a significant maintenance expense.

Eliminating the immediate financial burden of the tractor maintenance and supporting the critical parts of the reclaimed water irrigation system rehabilitation should enable the WUA to retain the surplus in its account, from which they could pay for routine maintenance requirements. The proposed work also includes training of farmers and WUA members, and the costs associated with the preparation of training materials. Trainers' fees are included in the implementation cost.

In the event that an external funding source is not identified in the near future, the Project team is prepared to revisit the scope and schedule for providing technical assistance to fit available funding, provide technical assistance in support of HFDB's efforts to seek alternative funding options, and continue to build WUA's financial management capacity to set aside part of their income for maintenance, repair and replacement of the irrigation system in the future.

**Table 4: Comparison of Purchasing or Renting a Tractor**

Purchasing		Renting	
Advantage	Disadvantage	Advantage	Disadvantage
Ownership of an asset	Maintenance cost	No initial cost, no maintenance cost other than fuel	Cannot count as an asset
Availability guaranteed			No guarantee of availability when needed
No transportation needed			Need to drive from renter's site to the farms
Good maintenance could extend the useable years	Poor maintenance could shorten the usable years		Quality of the machinery uncertain
Lower cost burden for farmers; Potential additional income through renting to external farmers	Cost burden for WUA	No cost burden for WUA	Higher cost burden for farmers
Cost comparison			
Purchasing		Renting	
Initial cost (estimated average)	24,500	Initial cost	0
Rent per hour (JOD)	0	Rent per day (JOD) <sup>a</sup>	5
Use per year (hr)	1350	Use per year (d)	420 <sup>b</sup>
Maintenance cost	10,200	Maintenance cost	10,400 (fuel)
Annual cost to WUA	4,800	Annual cost to WUA	0
Annual cost to farmers	5,400	Annual cost to farmers	12,500

<sup>a</sup> Assumed rent from a governmental agency. The cost does not include fuel and the farmer would drive it from the governmental facility to the pilot site. Fuel cost estimate based on 2 hrs driving and 2 hrs farming practices

<sup>b</sup> Assumed each farm unit will rent the tractor separately and there will be days when more than one tractor is rented for the pilot site

## 5. Technical Assistance Plan

The following technical assistance activities are proposed in this plan:

- Coordinating with HFDB to supervise the pilot
- Providing assistance to the management of the irrigation system operation and maintenance
- Developing Wadi Mousa project data base
- Opportunities to improve cropping patterns
- Assisting farmers to improve handling of agricultural products
- Training farmers and WUA staff

- Monitoring the development in the socioeconomic status of reclaimed water users
- Improve access to clean water for personal hygiene in the field (future plan)

Each of the above items is described in the following sections.

### **5.1 Coordination with HFDB for pilot project supervision**

Based on the two agreement documents (between WAJ and HFDB, and between HFDB and WUA), HFDB is responsible for supervising the pilot project and providing a project manager for the pilot. HFDB also holds partial financial responsibility to maintain the irrigation system components until 2012, based on the agreement with WUA. In this part of technical assistance, the project team will work with HFDB to establish a new MOU that delineates the role of HFDB in the Wadi Mousa pilot and the extent of cooperation between HFDB and the project.

The project team will coordinate with HFDB to designate an engineer as a point of contact for the farmers and WUA when the farmers need assistance in managing the pilot. Depending on the level of effort expected by the HFDB engineer, additional support may be sought to allow the farmers to have access to technical assistance during and after the project period (ending in July 2015).

### **5.2 Providing assistance to the management of the irrigation system operation and maintenance**

Technical assistance will be provided to build capacity for the farmers and the WUA to maintain best practices in the operation and maintenance of the reclaimed water irrigation system.

The first step to continue the pilot project is to identify and agree on the responsibilities of each stakeholder. Existing agreements will be revisited among the stakeholders with their responsibilities clearly defined.

According to the WUA, farmers at the Wadi Mousa project agreed orally that they are responsible for the maintenance and rehabilitation of their on-farm irrigation systems. However, there is no written agreement between the farmers and the WUA or any other parties in this respect. It is preferred to develop a written agreement between the WUA and farmers regarding the responsibility and accountability for irrigation network maintenance inside and outside farmers' fields.

The next step is to implement the operation and maintenance responsibilities according to the clarified roles. This effort will be led by HFDB, and the project team will facilitate the communication among the stakeholders. The activities needed include:

- Coordination with WAJ to implement the maintenance of the main conveyance lines transferring water to the project site
- Coordination with HFDB and WUA to inventory routine maintenance parts and the items in Appendix B that were not covered under the estimated costs for a proposed external funding source
- Coordination with HFDB, WUA and farmers to implement the maintenance/rehabilitation work according to the budget and urgency of the work (Detailed records of the damaged or missing parts needed for rehabilitation of the irrigation network at each farm are found in Appendix B)



The third step is to provide opportunities for the farmers and WUA to re-visit proper water management and the development of an irrigation schedule according to the requirements of the crops grown. The activities will be identified through discussion with farmers and WUA. Examples of potential activities include:

- Set guidelines for the irrigation schedules according to crop requirements and appropriate leaching factors
- Conduct a proper training plan that includes water management
  - Assist farmers in understanding the importance of proper irrigation water management in their fields in order to avoid over-irrigating or under-irrigating their crops.
- Match each distribution valve pits' capacity to deliver irrigation water with the total area of plots and grown crops
  - If necessary, make minor changes to the design of the existing irrigation network and if necessary, renumber all manholes and make necessary adjustments in the number of plots (addition, removal) receiving irrigation water from a certain manhole
- Monitor water meters installed at each farm to quantify water delivered to farmers' fields, and record the production of each crop
  - Farmers and WUA are responsible for protecting and maintaining water meters located at the farmers' fields

### 5.3 Developing Wadi Mousa Project Database

To improve the management of the Wadi Mousa pilot project, a database including information about the irrigation system, farm units, and other relevant information will be developed. Expected benefits of the database are:

- Providing a platform to collect, organize, and manage information related to the Wadi Mousa pilot project.
- Identifying information gaps for future activities.
- Reducing time, efforts, and costs needed to collect data in the future.
- Creating one database which will allow for a centralized method of updating information.

A model database for Wadi Mousa will be developed. The database will be suitable for use in setting up new reuse pilot projects with a vision for long-term economic sustainability. Development of a model database will include the following activities:

- Conduct a field survey to collect data and establish a coding system for the project site
- Develop a farm unit coding system that links each farm to the farmer planting it. This part of the data base was finalized
- Assess the suitability of plots (according to soil depth, slope gradient and other topographic features such as rock-outcrops and stoniness) for proper allocation of crops. The signed agreements (described further in Sec 3.2) clarified that the WUA of Sad Al-Ahmar and the HFDB are responsible for collecting and analyzing soil and plant samples, in addition to conducting monthly reports of the results. The data collected in accordance with the agreements would help populating the database.
- Investigate the irrigation network to obtain information regarding:
  - Inventory list for all equipment and components of the irrigation network (already developed)
  - Identification of damaged equipment and parts needed to fix the irrigation network (already done)

- The layout of main lines, laterals, and manifolds (developed under RIAL, to be confirmed by the project team)
- Develop maps that include actual farm areas and the layout of the irrigation system
- Conduct field surveys to collect information on socioeconomic status of farmers
- Compile information in the GIS, and also develop a simple spreadsheet-based database for the use by WUA
- Handover the database to HFDB and WUA
- After developing the database, the GIS-based database could be handed over to HFDB to facilitate the information sharing by whoever interested in water reuse issues. A simpler spreadsheet-type of database will be handed over to the WUA to systematically maintain and use the information for better future management of the pilot project going forward.

#### **5.4 Providing technical assistance for improving cropping pattern**

Comprehensive field evaluation revealed several problems affecting cropping patterns at the project site. Crop yields can be improved through implementing proper cropping patterns. Improved farming plans will be developed in cooperation between the farmers and the project team, and in consultation with NCARE, MoA and other experts, to maximize the resources available at the site and optimize the use of reclaimed water. The project team will seek the advice and recommendation of local experts working in similar institutions. The recommendations will include alternative cropping patterns, most proper and efficient irrigation schedules, increased use of native plants and trees suitable for grazing animals, proper pruning, fertilizing, and harvesting practices for fruit trees, and adaptation of crop rotation especially when direct grazing is practiced on the irrigated fields.

The project team will also recommend and assist in establishing activities within empty plots in the farms as follows:

- All empty plots should be cultivated, with alfalfa and other forage plants occupying at least 4 dunums per farm.
- In plots having substantial areas of rugged topography, saltbush plants (e.g. *Atriplex halimus*, *Salsola vermiculata*, and *Panicum miliaceum*) could be cultivated while direct grazing of the browse could be applied to save the costs of cutting and baling
- Wherever soil characteristics permit, crop rotation should be applied after termination of alfalfa stands. Typically, the rotation will be practiced every 4 years which is the normal average lifespan of alfalfa stands.
- It is suggested to plant Cactus trees as fences within the premises of the farms in order to separate plots used for rotating grazing activities and to delineate the farm's surrounding borders.

Introducing new species to the area raises the need for investigating the environmental impact of having new species introduced to Wadi Mousa site, e.g. Eucalyptus trees. It is worth noticing that the WWTP has already planted Eucalyptus trees inside the WWTP area, and these trees are standing successfully.

#### **5.5 Assisting farmers in improving the quality of their products**

At the Wadi Mousa pilot project, farmers are generating income from olives, barley, and alfalfa. Alfalfa is the most profitable crop in Wadi Mousa, while olive production covers farmers' household uses.



Farmers occasionally encounter difficulties selling their products because of poor handling and lack of experience. Improved alfalfa harvesting and storage strategies can raise product quality and improve marketability. The following activities are recommended in this respect:

- Maximize benefits through proper utilization of production
  - Alfalfa plants reaching 25-50% flowering stage should be cut at a height of 8-10 cm above ground level to encourage regrowth from the crown buds. Alfalfa is a multi-cut forage crop, and cutting is the best method to harvest the produced herbage.
  - Harvest in the late fall to increase tonnage of alfalfa recognizing that young alfalfa stands survive winters better than older stands.
  - Direct grazing of forage crops is usually not recommended because of the detrimental effect of grazing on alfalfa regrowth buds and the high potential of spreading weeds via animal droppings. However, the project will be seeking the advice of local experts and agronomists in order to reach the best combination of crops and native forage plants that will allow efficient and non-harmful grazing.
- Apply new storage and packaging strategies
  - Information on how many tons of forage can be marketed in Wadi Mousa and the surrounding areas should be available before drafting different scenarios for marketing the produced forage.
  - Making silage from produced forage is an option to conserve and market the surpluses of forage material. Farmers could be trained by The Jordanian Society for Organic Farming who is recently establishing a silage unit at Khirbet Al Samra area.

## 5.6 Training farmers and the WUA staff

The RIAL project trained farmers and WUA members who are responsible for operating the irrigation network on how to properly handle treated wastewater. There were no documented cases of illness resulting from contact with wastewater; however, the project's plan will include further training for farmers on how to use reclaimed water safely. The RIAL project established a simple irrigation schedule so that farmers can manage their farm units without dealing with a complicated irrigation management, and the resident engineer supervised the irrigation practice, crop harvesting and handling during the project period. The resident engineer left Wadi Mousa in 2009.

In the meetings with farmers and the WUA, and in field reviews, the project team discussed the challenges that face the use of reclaimed waste water for irrigation. This information will be used to develop the training plan. Advanced training of farmers is critical to increase the efficiency of their work and meet the challenges they face.

During the RIAL project, 35 farmers were trained, while currently 42 farmers are performing agricultural activities at Wadi Mousa. The training plan will include all farmers, regardless of whether they have attended previous trainings. As agreed in the signed contract between the HFDB and the WUA, the training of the WUA staff is the responsibility of the HFDB. Thus the project team will coordinate with HFDB for any future training activities. The training plan for farmers will be developed in consultation with HFDB, local experts, and other stakeholders, and is expected to include the following topics:

- Protection of farmers and secondary users of the products from health risks associated with the use of reclaimed water
- Crop patterns and the mixed cropping of native grasses, trees and shrubs for forage uses

- Crop harvesting, proper packaging and storage methods to maximize the value of the crops
- Crop water requirements, irrigation efficiency, and salinity control
- Control of pests, weeds, and diseases
- Agricultural business planning

The training effort on hygienic and safe reuse of reclaimed waste water may be coordinated with the Ministry of Health (MoH). The training effort on cropping patterns, crop handling will be coordinated with the engineer from HFDB and potentially with the Ministry of Agriculture (MoA) and the National Center for Agricultural Research and Extension (NCARE). Farmers at Wadi Mousa have been using reclaimed water for irrigation purposes for ten years by now. The farmers who received training can train other farmers at other reclaimed water reuse pilot projects in Jordan. Intensive training may be provided for one of the farmers who is a board member of the WUA, to allow him/her to provide assistance to other farmers after the completion of this project. The following activities are needed to develop the training.

- Consulting with farmers, WUA, and experts to determine the training needs.
- Preparing a training plan.
- Implementing the planned training sessions.

## **5.7 Socioeconomic Status Monitoring**

Achieving the sustainability of the Wadi Mousa pilot project is a main objective of this work plan. Because it is clear that the project sustainability depends mainly on the benefits of the project, it is important to encourage the practices that will eventually result in optimizing farmer benefits. A socioeconomic study will be conducted to evaluate the current socioeconomic status of the Wadi Mousa farmers and to monitor the success of the technical assistance. The evaluation will include the social and tribal status, income, family members, and economical status for both farmers and the WUA staff. The WUA will be evaluated for the number of members and the beneficiaries as well as the financial sustainability and the association's governance. The scope of the survey will be developed in consultation with the WUA and HFDB, and in reference to the USAID country strategy.

## **5.8 Improving Hygiene by Establishing Access to Clean Water**

For their safety, farmers were informed that the use of reclaimed water is strictly for irrigation and not for any other purposes. Cleaning, drinking, and washing require a clean water source. Farmers were trained by the RIAL project on the proper hygiene for handling reclaimed water. It is deemed necessary to have a source of clean, potable water near their farms to help farm workers abide by their training mandates. This project will consider providing the farmers in Wadi Mousa with a source of clean fresh water for hygienic purposes.

However, any activity related to this matter will be postponed for later stages of the project, because of the need for more investigations regarding costs and procedures, before reaching a feasible solution.

## **6. Stakeholders**

The key stakeholders of Wadi Mousa water reuse pilot project are the Water Authority of Jordan (WAJ), Hashemite Fund for Development of Jordan Badia (HFDB), Sad Al Ahmar Water Users Association (WUA), and individual farmers working in the field. Petra Regional Authority is the authority issuing permissions to grow certain plants at the pilot project site.

There are two memoranda of understanding currently in effect for the water reuse pilot project: (1) MOU between MWI and HFDB, and (2) MOU between HFDB and WUA. According to the agreements,

- MWI/WAJ:
  - MOU was signed by the Ministry of Water and Irrigation (MWI).
  - WAJ is the owner and operator of the WWTP.
- WUA:
  - Responsible for developing an agreement between WUA and farmers that will specify requirements for safe reuse practices according to the Jordanian standards.
  - Agreed to submit monthly progress and financial reports to HFDB.
- HFDB:
  - Has the right of administration and supervision of the WUA and its financial documents, as well as the right to direct it towards better performance.
  - Responsible for building the capacity of WUA so it can meet the qualifications needed for managing the project in a way that guarantees the pilot project's sustainability
  - Aside from the land ownership, HFDB was identified as the owner of Wadi Mousa pilot project components. After improving its capability in sustaining the project by itself, the WAU will be the owner of these components.

## **7. Technical Assistance Schedule**

The timeline for activities of the proposed work plan is presented in Table 5. The proposed schedule is dependent on identification of an external funding source in Quarter 1. Activities and responsibilities by WUA and farmers that stem from the work plan will be embedded in the agreement between WUA and farmers. If an external funding source cannot be identified within the foreseeable future, the technical assistance plan and schedule will be revisited with HFDB to determine which of the activities could be implemented without an external funding source.

Tasks and Activities	Year 1				Year 2				Responsibility
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	
<b>1. Coordination with HFDB</b>	X	X	X	X	X	X	X	X	Project/HFDB
<b>2. Providing assistance in the management of the irrigation system maintenance</b>									Project
A. Coordination with WAJ to rehabilitate the main conveyance line transferring water to the project site.	X	X	X						
B. Providing technical assistance to farmers for the rehabilitation of the on-farm irrigation networks.	X	X	X	X					
C. Assistance in proper water management and development of irrigation schedule according to the requirements of grown crops			X	X	X	X			
<b>3. Developing Wadi Mousa Project Database</b>									Project
A. Field survey, data collection and establishment of a coding system for the project site	X	X							
B. Develop maps that include actual farms' areas and the layout of the irrigation system	X	X							
C. Conduct field surveys to collect information on socioeconomic status of farmers	X	X	X	X	X	X	X	X	
D. Compile information in the GIS, and also develop a simple spreadsheet-based database for the use by WUA	X	X	X	X	X	X			
E. Handing over the database to WUA and HFDB					X	X	X	X	
<b>4. Providing technical assistance for improving cropping pattern.</b>	X	X	X	X	X	X			HFDB
<b>5. Assisting farmers in improving the quality of their products</b>									
A. Maximize benefits through proper utilization of production	X	X	X	X					
B. Apply new storage and packaging strategies				X	X	X			
<b>6. Training farmers and the WUA staff</b>									Project
A. Consulting with farmers, WUA, and experts to determine the training needs.	X	X	X						
B. Preparing a training plan.			X	X					
C. Implementing the planned training sessions			X	X	X	X	X	X	
<b>7. Socioeconomic Status Monitoring</b>	X	X	X	X	X	X	X	X	Project
<b>8. Establishing a Fresh Water Access Service</b>									

## References

- USAID. 2004-2007. Reuse for Industry, Agriculture and Landscaping Project (RIAL)  
Report: Baseline Report on Conditions at Reuse Demonstration Sites, 2004  
Report: Wadi Mousa Environmental Review Final Report, 2006  
Report: Impact Assessment of the RIAL Project, 2006  
Report: Reuse for Industry, Agriculture and Landscaping (RIAL) Project–Task 2  
Completion Report, 2007  
Report: Final Report, 2008  
RIAL training Plan, 2004
- USAID. 2011. Water Reuse and Environmental Conservation Project. Task 4 Report:  
Technical Memorandum II, Comprehensive Review of Water Reuse Pilot Projects.



## APPENDIX A

### Field Survey Summary

Field investigations were conducted at Wadi Mousa pilot project site on manholes and irrigation network in September and December 2011. The visits also included meeting with farmers and administrative personnel of Sad Al-Ahmar Water Users Association (WUA) at Wadi Mousa. The following information was collected from the site visits:

- Irrigation network evaluation
- Current cropping pattern
- Current Socioeconomic status

### Appendix A.1 Evaluation of the Irrigation Network

#### Irrigation network components:

The irrigation network consists of two electric pumps, two sand filters, underground 160 mm UPVC main conveyance line, 90mm and 160mm HDPE main lines conveying water to 41 farms, as well as farms' irrigation systems. The irrigation system at each farm consists of main line, manifolds, laterals, and head units.

Head units at each farm were inspected for any missing, damaged, or malfunctioning parts and equipment to identify the needed rehabilitation for the irrigation network. Each head unit consists of gate valve, disc filter, flow meter, fertilization unit, and pressure regulator. The detailed records of the damaged or missing parts of the irrigation network at each farm can be found in Appendix B.

Based on the irrigation system tender documents developed by RIAL, the project team estimated the materials needed for rehabilitation. Drawing, specifications and bill of quantity were specified in the tender document.

Regarding irrigation system design, the following observations were made:

- Leaking from the UPVC main line due to line fracture.
- Unused valves and manholes on the main conveyance line.
- Manhole connections do not match the number of farm main lines. For example, manhole no. 3 is connected to four farms, while manhole no. 2 is connected to one farm only
- At the farm scale:
  - Overdesigned farm main lines; for example farms no. 6, 14, and 15.
  - Head units:
    - Leaking joints (Figure 1)
    - The disc filter's cartridge was removed in most head units due to clogging by sediments (Figure 2-a)
    - Head units at each farm include pressure regulators, regardless of the farm's location or elevation. In most head units, pressure regulators were removed or not operational due to either being damaged or lack of spare parts (Figure 2-b)
    - Fertilizer units are not operational due to broken valves
    - Most of the flow meters are damaged (Figure 2-c)
- Laterals:



- Consist of in-line emitters, with 20mm diameter and one meter apart.
- The layout of the 20 mm GR for laterals does not go with the contour lines. (Figure 3)
- Most of the 20 mm GR lateral lines are damaged and should be replaced.
- Leakages appear in the connection points to the manifolds as well as from the 20mm line.
- Random distribution of the 20mm line: the distances between 20mm lines are not consistent and vary from 1 to 2m
- 20mm line endings were manually tied.
- Clogged emitters.
- Fruit tree emitters were not in place.



Figure A-1: leakage points detected at farms in Wadi Mousa pilot project.



Figure A-2: Detected damages at farm's head units in Wadi Mousa pilot project.



Figure A-3: Laterals lay out at Wadi Mousa pilot project's farms.

### Irrigation System Performance

Drip irrigation systems are used to improve the efficiency of irrigation with reclaimed water. They must be managed well to avoid possible leakage or clogging, because drip emitters



can be clogged easily by particles in the irrigation water. This was noticed clearly during the field visit to Wadi Mousa pilot project.

Regarding the irrigation network performance, the following observations were made:

- Some farms are over irrigated, while others are water stressed.
- Alfalfa is no longer planted in some farms due to the deterioration of the drippers and laterals.
- Water runoff due to long operation time.
- Water loss, due to irrigating non-productive fruit trees.
- Leakage from filters, pipes, joints, valves, and emitters.

## Appendix A.2 Cropping Pattern

The project team investigated the cropping pattern at each farm unit, and recorded the area occupied by crops at some farms (permanent and winter). Data on actual areas of farm plots were not available. Winter crops (mainly Barley), alfalfa, and fruit trees occupied 47%, 40% and 13% of the total area of the pilot project at Wadi Mousa, respectively (Figure 4). However, the 47% of land dedicated to be planted with barley was still bare, waiting for winter.

Phase I farms were planted by forage crops (alfalfa, wheat, and barley), and trees such as; olives, figs, grapes, guava, kaka, lemon, pomegranate, and cactus. For alfalfa, each farmer was allowed to plant 4 dunums only. Phase II farms were allowed to cultivate any crop except trees as long as planting of alfalfa did not exceed 4 dunums at each farm unit. Thus, part of the farm in most farm units was left without planting, waiting to be planted with winter crops. For both Phases I and II farms, part of the farm area was left without cultivation, even the areas allocated to alfalfa. However, farmers did not consider crop rotation in their plantings.

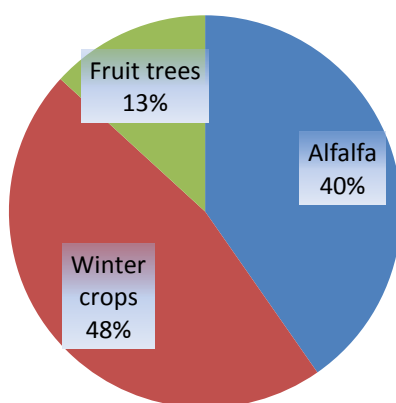
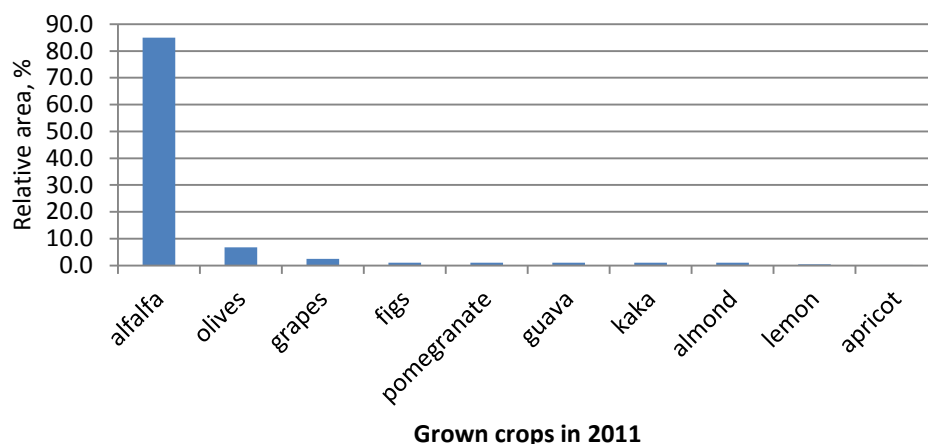


Figure A-4: Percent of main crops of cultivated areas at the water reuse site in Wadi Mousa.

For the currently cultivated areas, the cropping pattern was as follows (Figure 5);

- 85% for alfalfa
- 6.7% for olives
- 2.5% for grapes
- Less than 1% for figs, pomegranates, guavas, kakas, almonds, lemons and apricots



**Figure A-5: Relative area (%) of grown crops at the water reuse site in Wadi Mousa.**

Alfalfa and olives are growing well at the site in terms of production and economics (Figure 6). The percentage of land covered by the plant for each of main crops grown at the site was: alfalfa (90.0%), olives (58.0%) and grapes (30%).

It is well known that alfalfa plants should be cut at a certain height above ground (8-10 cm) to give the crop an opportunity to re-grow from the buds located at the growing point near the soil surface. Direct grazing of alfalfa plants, noticed at some farms, is harmful and results in spot or patch grazing (spots without plants) in the field which is an indication of damaged plants. During the field visit, camels were grazing in alfalfa fields and symptoms of damaged plants were obvious (Figure 7).



**Figure A-6: Robust growth and lack of pruning olive trees at the water reuse site in Wadi Mousa.**



**Figure A-7: Camel direct grazing alfalfa plants at the water reuse sites in Wadi Mousa.**

The following issues affecting successful cropping pattern at the project site should be noted:

- Phase II farmers are not allowed to cultivate trees at their farms.
- Phase I farms included planted trees. Aside from olives, all other tree crops were found as either unsuccessful or nonprofit able under reclaimed water irrigation at Wadi Mousa pilot project.
- Direct grazing of alfalfa plants, noticed at some farms, affects uniform crop growth and yield.
- Crop rotation was not considered.
- Over-irrigating and under-irrigating practices by some farmers affect crop yields.
- Empty uncultivated spots within farm units were noticeable.
- Growth of unwanted weeds and grasses in between trees

### **Appendix A.3 Socioeconomic Status**

The socioeconomic status of Wadi Mousa pilot project was evaluated through site visits, contacting HFDB, and meeting with both WUA's administrators and farmers. The following points were evaluated as well:

- The WUA financial setup
- Agricultural performance and socioeconomic status of water users (farmers)
- Marketing strategies used in Wadi Mousa pilot project

### **Review of the WUA Financial Setup**

The Water Users Association (WUA) at Wadi Mousa pilot project is represented by Sad Al-Ahmar Association. The two key persons running the WUA are the Vice Chairman of the Association (Salem Abu-Shousha) and the Secretary (Ahmad Hlalat). The WUA is struggling to provide necessary funds for securing essential services to farmers. The services include plowing, cutting, and baling of alfalfa plants, harvesting of barley grains, and supervising the irrigation schedule. The WUA is responsible for providing the needed machinery to farmers, as well as related operational and maintenance costs. Participation of farmers in the decision making process was not clear.

The financial setup of WUA was evaluated through meeting with the association administrators, and reviewing their financial documents. The WUA financial documents include two balance sheets for the years 2005-2008 and two profit and Loss sheets (P&L): one for the year 2006 and the other for year 2008. These documents were reviewed and approved by the Department of Audit in the Jordanian Cooperative Corporation (JCC). The analysis of the formal financial sheets for year 2010 revealed the following:

- The income of the association was around 17,000 JD
- The net operating profit before taxes and interests was JD 3964.575
- Since there are no taxes, and the cooperative did not get loans, the same amount is considered as profits ready for distribution
- The total value of equity in 2010 was JD 8139.575
- The total assets plus equity were JD 45014.790



**Figure A-8: meeting with Sad Al-Ahmar Water Users Association at Wadi Mousa.**

WUA bought two tractors: The first is a big John Deere tractor (Figure 9), and the second is a small one used to cultivate between the fruit trees. The John Deere tractor was imported from USA directly, and thus the spare parts were not available at the local market. Lately, the hydraulic system was broken, so the association put a locally crafted one which is not as efficient as the original. However, the small tractor is working well.

In addition, WUA owns two alfalfa cutters, one baler, one disc plough and one duck-leg plough. All are working well. It also owns some office furniture and a kitchen oven. Reviewing the financial documents of WUA, it was found that most of the association revenues are consumed in the operation and maintenance of the machinery, with the highest costs going for the John Deere Tractor's maintenance.



**Figure A-9: The John Deere tractor belongs to WUA.**

However, further investigation in the financial setup of WUA is needed for better interpretation of the kind of technical assistance the association will need for developing its financial setup, thus ensuring its sustainability and its efficiency in providing the needed assistance for its members.

Meeting with WUA, revealed the following concerns:

- No available cash for the revolving fund, from which farmers can benefit and use for the rehabilitation of the on-farm irrigation networks.
- No available spare parts for the farms' irrigation systems in close area. Farmers need to travel to Amman to buy these spare parts.
- Low pressures in farms' turn outs within Phase II farm units. Farmers are requesting technical and financial support for rehabilitating the irrigation network.
- No available spare parts for the John Deere tractor. Farmers need to import them directly from USA, at a very high cost. Having said this, they suggested helping them to get funding for a new tractor with available spare parts in the local market. (Appendix D)

## **Agricultural performance and socioeconomic status of water users (farmers)**

RIAL established The Water Users Association at Wadi Mousa pilot project site, to operate and manage agricultural activities conducted within the project. The WUA has a president and a secretary. The number of WUA members reached 114 by the end of 2010; with 42

beneficiary members cultivating their farms at Wadi Mousa pilot project. The rest (72) are complaining for not being included in the project. Farmers requested the introduction of new projects through the association for the non-beneficiary members or including these members in other projects implemented by other associations. The requested projects by farmers are beekeeping and sheep growing.

Most of the farmers who were allocated land to cultivate were new to the practice of irrigating with treated waste water, the rest were military retired personnel who were not familiar with farming and irrigation. Due to this fact, RIAL project conducted several training courses for these farmers on safe reuse. RIAL's documents showed plans to train 35 farmers on safe reuse. Hlalat, the secretary of WUA confirmed that, in 2005, 35 farmers were trained in safe reuse and are currently committed to it.

The training was planned as six 1-2 day workshops on the following topics: organization and management, credit mechanism/revolving fund, marketing, public health, operations and maintenance, and on-farm management. The training plan was developed by a U.S. training specialist from the Training Resources Group (TRG) in close collaboration with two RIAL Project staff members. Training on public health aspects included safe reuse of reclaimed water for both operators and users. Operators and technicians follow guidelines for proper clothing, occupational safety and hygienic practices.

More investigations of the actual farmers' training needs are critical. This can be performed through meeting all beneficiary members of WUA and other potential farmers who are still considered non-beneficiaries.

### **Appendix A.3.3: Marketing strategies used in Wadi Mousa pilot project**

Each member was allowed to cultivate 0.4 ha for alfalfa production; the rest of the land is planted with fruit trees; mainly olives, lemons, guava, and barley. The main cash crop in the project is alfalfa. The fruit trees have been planted 5-6 years ago, yet their production is still low. Alfalfa is given as feed for sheep or sold or stored as green or hay. Most of the farmers using reclaimed water are raising sheep.

The farmers claimed they are facing problems in marketing the alfalfa because it is irrigated by reclaimed water. The farmers shipped some bales of alfalfa to dairy farms in Shoubak, a neighboring village with dairy cow activities. The bales were not dried well, and the inner parts were wet and rotten, so farmers were not able to sell their produce in Shoubak once more. However, calculating the returns and costs of producing alfalfa showed that it is profitable, irrespective of the bad marketing practices. More details regarding the income of farmers can be found on the Comprehensive Review of Water Reuse Pilot Projects Report, 2011.

## APPENDIX B

Missing, broken and malfunctioning parts of the irrigation network at each farm of the Wadi Mousa Pilot Project.

ITEM DESCRIPTION	Farm No.																																			
	1	3	8	14	15	9	6	5	10	13	11	12	18	19	17	23	25	20	22	30	29	36	28	27	37	26	35	38	34	31	33	32	41	Aziza	Mariam	Mousa

### Farm Head Unit

Supply, install, test and maintain with all accessories necessary, complete as per specifications																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							</
---	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	----

### Fittings

USAID Water Reuse and Environmental Conservation Project  
Wadi Mousa Reuse Pilot Project Technical Assistance Plan

[illegible]

## APPENDIX C

### Estimated Costs for Irrigation System Rehabilitation for Wadi Mousa Pilot Project

#### 1. Conveyance line from wastewater treatment plant to the pilot project area

Work on the pump station: supply, install, test and provide maintenance with all accessories necessary, complete as per specifications

Work on the sand filters: maintain valves, paint, and install rubber to stop the leak from sand filters, and provide maintenance the concrete base with all accessories necessary to complete the work

ITEM DESCRIPTION	UNIT	QTY	Working Pressure (bar)	Material Origin	Unit Price J.D	Total Cost J.D
<b><u>Pump station</u></b>						
*One Vertical Multi-stage pump (Q=30 m3/hr@ 3.5 bar)						
* Variable speed, Variable frequency drive ( VFD)						
* Electrical Control Panel and protections						
* Pressure Vessel 100L						
* Pressure transmitter						
* Piping						
* Valves						
* Strainer						
* Non-return valves						
* Fittings						
* All materials required to complete the works	No.	1	3.5	Denmark	6,200.00	6,200.00
Fix leakage for 6" valve	No.	1	Flange valve		75.00	75.00
Fix leakage for reducer 8"-6"	No.	1			75.00	75.00
Gasket for 8" flange valve	No.	1			50.00	50.00
<b><u>Sand Filters</u></b>						
Sand Filters	No.	3	epoxy coated		300.00	900.00



## 2. Irrigation system sub-main to farms

Work on farm head units, valves and fittings: Supply, install, test and provide maintenance with all accessories necessary, complete as per specifications

ITEM DESCRIPTION	UNIT	QTY	Working Pressure (bar)	Material Origin	Unit Price J.D	Total cost J.D
<b><u>Farm Head Unit</u></b>						
3"- Flanged Flow meter	No.	15	10	China, Poland	320.00	4,800.00
3"- Disc filter	No.	23	20	KSA	250.00	5,750.00
3" - Pressure regulator	No.	11	20	Italy	650.00	7,150.00
1.5" - Venturi fertilizer	No.	14		USA	150.00	2,100.00
Cartridge ( Disc ) for 3" disc filter	No.	9		KSA	75.00	675.00
Accessories for 3" pressure regulator	No.	10		Local	20.00	200.00
Accessories for 1.5" Venturi fertilizer	No.	15		Italy	35.00	525.00
Pressure gauge	No.	84	20	Italy	9.00	756.00
<b><u>Valves:</u></b>						
4"- Flanged valve	No.	3	20	Italy	350.00	1,050.00
4" - Threaded valve	No.	1	20	Italy	150.00	150.00
3" - Flanged valve	No.	1	20	Italy	250.00	250.00
3"- Threaded valve	No.	6	20	Italy	75.00	450.00
<b><u>Fittings</u></b>						
Clamp saddle with reinforced ring 125* 2"	No.	1	16	KSA	6.50	6.50
PE Male adapter 90x3"	No.	9	16	KSA	8.50	76.50
PE Coupling 110mm	No.	2	16	KSA	23.00	46.00
PE Coupling 90mm	No.	2	16	KSA	15.00	30.00
PE Elbow 3"	No.	2	20	White Iron	25.00	50.00
Nipple 3"	No.	1	20	White Iron	25.00	25.00
Air release valve 2"	No.	1	10	KSA, Italy	50.00	50.00

### 3. Farm units

Work on farm units: Supply, install, test and provide maintenance as per specifications and as shown on drawings, HDPE pipes (working pressure 16 bar) for irrigation system, pipes shall include all fittings such as elbows, tees, unions, adapters, reducers, "Y" connections and all accessories necessary to complete the work such as chasing, cutting, excavation and refilling. LDPE (working pressure 4 bar) polyethylene pipes with all accessories necessary to complete the work for irrigation lateral

ITEM DESCRIPTION	UNIT	QTY	Working Pressure (bar)	Material Origin	Unit Price J.D	Total cost J.D
<b><u>HDPE Pipes - Farms</u></b>						
HDPE pipe ø 90 mm - 16 bar, Purple	M	250	16		5.50	1,375.00
<b><u>LDPE Pipes - Farms</u></b>						
LDPE pipe ø 20 mm - 4 bar 1.8 mm wall thickness, Purple	M	2000	4		0.14	280.00
LDPE pipe ø 20 mm - 4 bar inline emitter pipe GR, 12 lph/m, Purple	M	65200	4		0.18	11,736.00
Rubber 20mm	No.	2000			0.05	100.00
Elbow 20mm	No.	2000			0.05	100.00
Coupling 20mm	No.	2000			0.05	100.00
End plug 20mm	No.	2000			0.05	100.00
PE Male adapter 63x2"	No.	20	16	KSA	4.30	86.00
PE Male adapter 50x1.5"	No.	12	16	KSA	3.20	38.40
PE Elbow 63x2"	No.	20	16	KSA	6.50	130.00

**ESTIMATED GRAND TOTAL FOR IRRIGATION SYSTEM REHABILITATION**

**45,985 JOD**

## APPENDIX D

2010 accounting record (translated from Arabic)			
Income	Amount, JOD	Expenses	Amount, JOD
Bailer rent income	4945.5	Salaries	5095.5
Land rent income	3370	Participation fees in committees	1560
Mower rent income	2797	Fuel	1408.7
Harvester rent income	2603	Maintenance of machinery	1165.365
Land plowing income	836	Bailer threads	300
Land subscription income	900	Machinery transportation fees	250
Land survey income	41	Accounting services	250
<b>Subtotal</b>	<b>15492.5</b>	Blades for harvester	190
<b>Membership fees</b>	<b>100</b>	Oil and lubrication fees	261.75
		Mower plating	175
		Mobile phone cards	128.25
		Transportation fees	90
		Transportation fees (fuel)	80
		Office fees	49.7
		stationery	44.75
		Maintenance of filters (tractor)	20
		Workers' fees	10
		Bank fees	3.9
		<b>Subtotal</b>	<b>11082.915</b>
		Auditing fees	85
		Services fees	110
		<b>Subtotal</b>	<b>195</b>
		<b>Depreciation of machinery</b>	<b>350</b>
		<b>Surplus</b>	<b>3964.585</b>
<b>TOTAL</b>	<b>15592.5</b>		<b>15592.5</b>

## APPENDIX E

Information Provided by Menjal Aric Est., and Khalil Khouri & Sons, 2012

<b>Tractor</b>	<b>Made In</b>	<b>Power (hp)</b>	<b>Cost (JD)</b>	<b>Estimated annual O&amp;M (JD)</b>
<b>Kioto DS4510</b>	Korea	45	12,500	5,400
<b>Massey Ferguson M385, manual steering</b>	Pakistan	50	8,900	5,500
<b>Massey Ferguson M240, power steering</b>	Pakistan	50	9,400	5,500
<b>Massey Ferguson MF375</b>	Pakistan	75	13,500	8,200
<b>Massey Ferguson MF375, with a driver room</b>	Pakistan	75	15,500	8,400
<b>Massey Ferguson M385</b>	Pakistan	85	19,500	9,700
<b>Massey Tashkent 285</b>	Turkey	85	24,500	10,200
<b>Kioti Dk1002</b>	Korea	100	29,000	12,000